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August 28, 2000

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BOX: PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Re: Application of **Oh-sang KWON**
DIGITAL ECHO CANCELLATION DEVICE
Our Reference: Q60491

Dear Sir:

Attached hereto is the application identified above including the specification, claims, executed Declaration and Power of Attorney, three (3) sheets of drawings, one (1) priority document, executed Assignment and PTO Form 1595.

The Government filing fee is calculated as follows:

Total Claims	5 - 20 =	0 x $18 =	$ 000.00
Independent Claims	2 - 3 =	0 x $78 =	$ 000.00
Base Filing Fee	($690.00)		$ 690.00
Multiple Dep. Claim Fee	($260.00)		$ 000.00
TOTAL FILING FEE			**$ 690.00**
Recordation of Assignment Fee			$ 40.00
TOTAL U.S. GOVERNMENT FEE			**$ 730.00**

Checks for the statutory filing fee of **$ 690.00** and Assignment recordation fee of **$ 40.00** are attached. You are also directed and authorized to charge or credit any difference or overpayment to Deposit Account No. 19-4880. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. 1.16 and 1.17 and any petitions for extension of time under 37 C.F.R. 1.136 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from:

Korean Patent Application	Filing Date
99-35838	August 27, 1999

The Office's attention is directed to the signature of the inventor on the attached executed documents. The inventor correctly signed his name according to the name order used in his country with the family name being set forth first. Accordingly, the typed name of the inventor and the signature of the inventor do correspond with each other.

Since the anniversary of the priority date fell on a Sunday, August 27, 2000, the filing of this application on Monday, August 28, 2000 is sufficient to obtain the benefit of priority.

Respectfully submitted,
SUGHRUE, MION, ZINN, MACPEAK & SEAS
Attorneys for Applicant(s)

By Paul E. Mixo Reg. 33,102
for Darryl Mexic
Registration No. 23,063

DM:maa

DIGITAL ECHO CANCELLATION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a digital echo cancellation device, and more particularly, to a digital echo cancellation device having improved convergence with a small amount of calculation and a small amount of memory.

2. Description of the Related Art

In the field of high speed communication applications such as asymmetric digital subscriber's line (ADSL), echo is common communications problem. Therefore, research has been conducted regarding apparatuses and technologies for removing echo.

A conventional echo cancellation device is disclosed in U.S. Patent No. 4,268,727, entitled "Adaptive Digital Echo Cancellation Circuit," registered on May 19, 1981, and issued to Agrawal et al. FIG. 1 is a block diagram showing the structure of the digital echo cancellation device disclosed in U.S. Patent No. 4,268,727. Referring to FIG. 1, the conventional digital echo cancellation device includes a finite impulse response (FIR) filter and a correlator 32 for compensating for the coefficient of an adaptive filter using a correlation between a receive signal 102 and a send signal 104.

However, in the conventional digital echo cancellation device, many taps are required since the conventional digital echo cancellation device is constituted of an adaptive FIR filter and it takes a long time to obtain the optimal resolution since a least mean square (LMS) algorithm is used for compensating for the filter coefficient. In particular, when signals, in which a high correlation exists between each other, such as aural signals are input, convergence deteriorates and time spent on canceling echo increases.

Another conventional technology for solving the above problem is disclosed in U.S. Patent No. 5,084,865, entitled "Echo Canceler Having FIR and IIR Filter for Canceling Long Tail Echos," registered on January 28, 1992, and issued to Koike. FIG. 2 is a block diagram showing the structure of a digital echo cancellation device, disclosed in U.S. Patent No. 5,084,865. Referring to FIG. 2, another conventional digital echo cancellation device includes an FIR filter 6 and a tail canceler 7, which are connected to a hybrid 1. The tail canceler 7 includes an infinite impulse response (IIR) filter 24. After delay signals pass through the tapped delay line of the FIR filter 6, they are repeatedly multiplied with each other by the multiplier 14 of the IIR filter 24, and a correlator 22 compensates for the filter coefficient.

In the above digital echo cancellation device, the amount of calculation is reduced by using two-stage FIR and IIR filters, however, the stability of the output of the post-stage IIR filter deteriorates.

SUMMARY OF THE INVENTION

To solve the above problems, it is an object of the present invention to provide an echo cancellation device capable of reducing the amount of calculation and the amount of memory and improving the stability of the output of a filter.

Accordingly, to achieve the above object, according to an aspect of the present invention, there is provided a digital echo cancellation device used for a high speed bidirectional communication system, comprising an adaptive beamformer in the form an finite impulse response (FIR) filter for estimating an input receiving signal, the adaptive beamformer for estimating a front part, which rapidly changes in an echo path impulse response, by adaptively estimating the input receiving signal and an orthogonalized infinite impulse response (IIR) filter for receiving the estimated signal output from the adaptive

beamformer and estimating a hind part of the echo path impulse response on the basis of an IIR.

The digital echo cancellation device preferably further comprises a first adder for subtracting a signal output from the adaptive beamformer from a receiving signal and outputting a first error signal and a second adder for receiving the first error signal, subtracting the signal output from the orthogonalized IIR filter from the first error signal, and outputting a second error signal.

According to another aspect of the present invention, there is provided a digital echo cancellation device used for a high speed bidirectional communication system, comprising an adaptive beamformer in the form of a finite impulse response filter for estimating an input receiving signal, for estimating a front part which rapidly changes in an echo path impulse response by adaptively estimating the input receiving signal, an orthogonalized infinite impulse response (IIR) filter for receiving an estimated signal, which is output from the adaptive beamformer, and estimating a hind part of the echo path impulse response on the basis of an IIR, a first adder for subtracting a signal output from the adaptive beamformer from a receiving signal and outputting a first error signal, and a second adder for outputting a second error signal as a signal from which echo is canceled by subtracting the signal output from the IIR filter from the signal output from the first adder.

BRIEF DESCRIPTION OF THE DRAWING(S)

The above object and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1 is a block diagram illustrating the structure of a conventional digital echo cancellation device;

FIG. 2 is a block diagram illustrating the structure of another conventional digital echo cancellation device;

FIG. 3 is a block diagram schematically illustrating the structure of a digital echo cancellation device according to an embodiment of the present invention; and

FIG. 4 is a schematic diagram illustrating the structure of the digital echo cancellation device of FIG. 3 in detail.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIG. 3 is a block diagram schematically showing the structure of a digital echo cancellation device according to an embodiment of the present invention. Referring to FIG. 3, the digital echo cancellation device according to the present invention includes a hybrid 30, an adaptive beam former 32, an orthogonalized infinite impulse response filter (IIR) 34, a first adder 322, and a second adder 342.

The operation of the digital echo cancellation device will now be described. The adaptive beamformer 32 adaptively estimates an input receiving signal x(n). The orthogonalized IIR filter 34 receives the estimated signal output from the adaptive beamformer 32, generates an orthogonalized signal with respect to the estimated signal, and estimates the impulse response of an echo path.

In this device, it is possible to rapidly obtain the optimal resolution and to improve the stability of the output of the orthogonalized IIR filter 34 since the well-estimated signal output from the adaptive beamformer 32 is used as an input signal by the orthogonalized IIR filter 34. Further, it is possible to estimate a resolution using a small number of taps since the characteristics of the IIR filter are used by the orthogonalized IIR filter 34.

The adder 322 subtracts a lattice-type filter output signal y(n) generated by the adaptive beamformer 32 from a received

transmission signal d(n) and outputs a first error signal e1(n). The first error signal e1(n) is input to the adder 342 and an output signal z(n) of the orthogonalized IIR filter 34 is subtracted from the first error signal e1(n) to generate a second error signal e2(n). The second error signal e2(n) is an echo-canceled signal.

FIG. 4 shows the structure of the digital echo cancellation device of FIG. 3 in detail. Referring to FIG. 4, the adaptive beamformer 32 of the echo cancellation device according to the present invention includes a finite impulse response filter having M stages and an adder 420, where M is a predetermined positive number. A first stage includes a delay 424 and a coefficient b_0 422. Each of the M stages, which have the same structure as that of the first stage, are serially connected. The orthogonalized IIR filter 34 includes a stage 46A comprising a delay 460 and an adder 462 for adding the signal output from the adder 420 of the adaptive beamformer 32 to a signal obtained by multiplying a signal output from the delay 460 with the coefficient r. Further, the IIR filter 34 includes a stage 46B comprising a delay 468 and an adder 472 for adding to each other the signal obtained by multiplying a signal output from the stage 46A with a coefficient -r, a signal which passes through the delay 468, and the signal obtained by multiplying a signal output from a delay 474 with the coefficient r. The IIR filter 34 comprises an additional N-1 stages having the same configuration as that of the stage 46B which are serially connected to each other for a total of N stages.

The operation of the above digital echo cancellation device will now be described. The receiving signal x(n) is multiplied with coefficients $b_0, \ldots, b_{M-1}$, while passing through M delays. The signals multiplied with the coefficients $b_0, \ldots, b_{M-1}$, while passing through the M delays, are input to the adder 420. The received transmission signal d(n) is adaptively estimated by the M stages of the adaptive

beamformer 32. An adder 440 subtracts an estimated signal generated by the adaptive beamformer 32 from the receiving signal d(n) from which echo is to be canceled in order to generate the first error signal e1(n).

The adaptive beamformer 32 of the echo cancellation device according to the present invention estimates the front portion of an echo path impulse response with respect to a carrier serving area (CSA) loop. The front portion of the impulse response with respect to the CSA loop corresponds to a portion which rapidly changes in an impulse response characteristic curve. The signal estimated by passing through the adaptive beamformer 32 is provided to the orthogonalized IIR filter 34.

In the preferred embodiment, signals output from each of the N stages, where N is a predetermined positive number, are multiplied with coefficients $a_0, \ldots, a_{N-1}$ and the multiplication results are provided to an adder 482 which subtracts the first error signal e1(n) from the multiplication results to generate an echo-canceled second error signal e2(n).

The orthogonalized IIR filter 34 estimates a tail portion of the impulse response with respect to the CSA loop, that is, a tail portion of the echo path impulse response. The tail portion of the impulse response with respect to the CSA loop corresponds to a portion which is slowly reduced in the form of an exponent. The stability of the output of the IIR filter 34 is high since the signal estimated by passing through the adaptive beamformer 32 is used as an input and orthogonalized signals are used by the IIR filter 34.

According to the echo cancellation device of the present invention, it is possible to rapidly obtain the optimal resolution, to thus increase convergence speed since the well-estimated signal, which is output from the adaptive beamformer 32 is used as an input signal by

the orthogonalized IIR filter 34. Also, since the convergence speed increases, the performance of the echo cancellation device is improved. Furthermore, the stability of the output of the filter is improved by using the orthogonalized IIR filter.

Also, according to the echo cancellation device of the present invention, the amount of calculation and the amount of memory are significantly reduced since the impulse response of the echo path is estimated by only several tens of taps.

The echo cancellation device according to the present invention can be applied to high speed bidirectional communications such as a very high bit-rate subscriber line (VDSL) and a giga byte Ethernet as well as an asymmetric digital subscriber's line (ADSL), and effectively cancels echo. Accordingly, it is possible to significantly improve the performance of a communication service.

As mentioned above, according to the digital echo cancellation device according to the present invention, the amount of calculation and the amount of memory are significantly reduced since the impulse response of the echo path is estimated by only the several tens of taps.

What is claimed is:

1. A digital echo cancellation device used for a high speed bidirectional communication system, comprising:

an adaptive beamformer comprising an finite impulse response filter for estimating an input receiving signal, the adaptive beamformer estimating a front portion of an echo path impulse response by adaptively estimating the input receiving signal; and

an orthogonalized infinite impulse response (IIR) filter for receiving an estimated signal output from the adaptive beamformer and estimating an tail portion of the echo path impulse on the basis of an IIR.

2. The digital echo cancellation device of claim 1, further comprising:

a first adder for subtracting the estimated signal output from the adaptive beamformer from a receiving signal to generate a first error signal; and

a second adder for receiving the first error signal and subtracting the signal output from the orthogonalized IIR filter from the first error signal to generate a second error signal in which echo is canceled.

3. A digital echo cancellation device used for a high speed bidirectional communication system, comprising:

an adaptive beamformer comprising a finite impulse response filter for estimating an input receiving signal, the adaptive beamformer estimating a front portion of an echo path impulse response by adaptively estimating the input receiving signal;

an orthogonalized infinite impulse response (IIR) filter for receiving an estimated signal output from the adaptive beamformer and estimating a tail portion of the echo path impulse response on the basis of an IIR;

a first adder for subtracting the estimated signal output from the adaptive beamformer from a received transmission signal to generate a first error signal; and

a second adder for generating a second error signal from which echo is canceled by subtracting the signal output from the IIR filter from the first error signal.

4. The digital echo cancellation device of claim 3, wherein the orthogonalized IIR filter comprises:

a first stage comprising a first adder for receiving the estimated signal output from the adaptive beamformer and a first delay for delaying an output signal from the first adder, wherein the adder adds the estimated signal to a signal obtained by multiplying an output signal from the first delay with a coefficient r; and

a plurality of additional stages which are serially connected to each other, wherein a first one of the additional stages is connected to an output signal from the first stage and comprises a second delay for delaying the output signal from the first stage, a third delay, and a second adder for adding a signal obtained by multiplying the output signal from the first stage with a coefficient -r, an output signal of the second delay, and a signal obtained by multiplying an output signal from the third delay with the coefficient r.

5. The digital echo cancellation device of claim 3, wherein output signals from the from each of the additional stages are

multiplied by coefficients and then provided to the second adder to generate the second error signal.

Abstract of the Disclosure

A digital echo cancellation device is provided. The digital echo cancellation device used for a high speed bidirectional communication system includes an adaptive beamformer in the form of a plurality of finite impulse response (FIR) filters for estimating an input receiving signal, the adaptive beamformer for estimating a front part, which rapidly changes in an echo path impulse response, by adaptively estimating the input receiving signal and an orthogonalized infinite impulse response (IIR) filter for receiving the estimated signal output from the adaptive beamformer and estimating a hind part of the echo path impulse response on the basis of an IIR. According to the digital echo cancellation device, the amount of calculation and the amount of required memory is significantly reduced, convergence speed is high, and the stability of the output of the filter is improved since the impulse response of the echo path is estimated by only several tens of taps.

FIG. 1 (PRIOR ART)

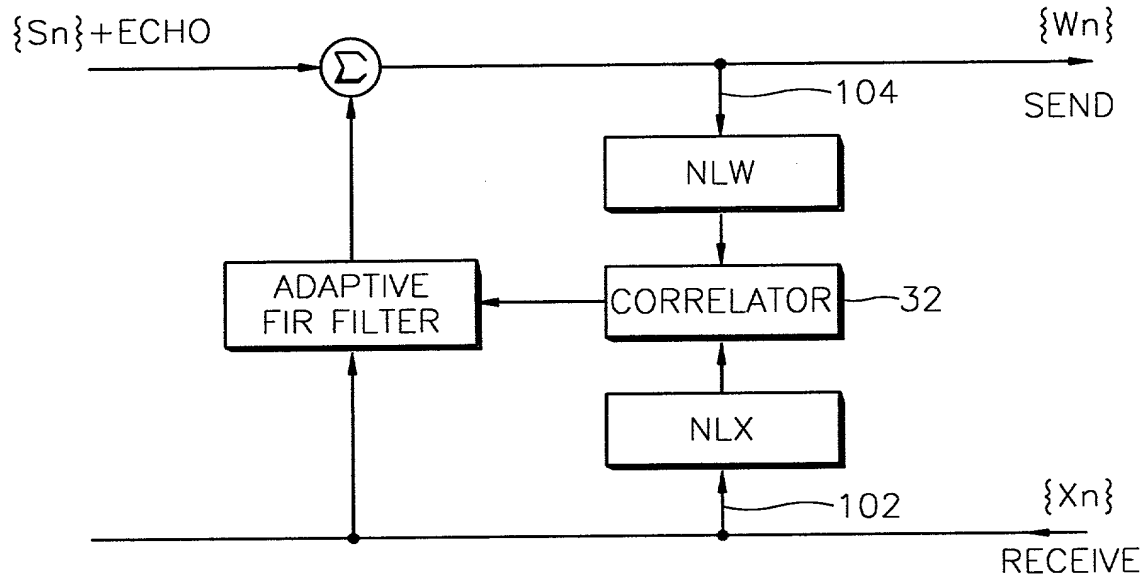


FIG. 3

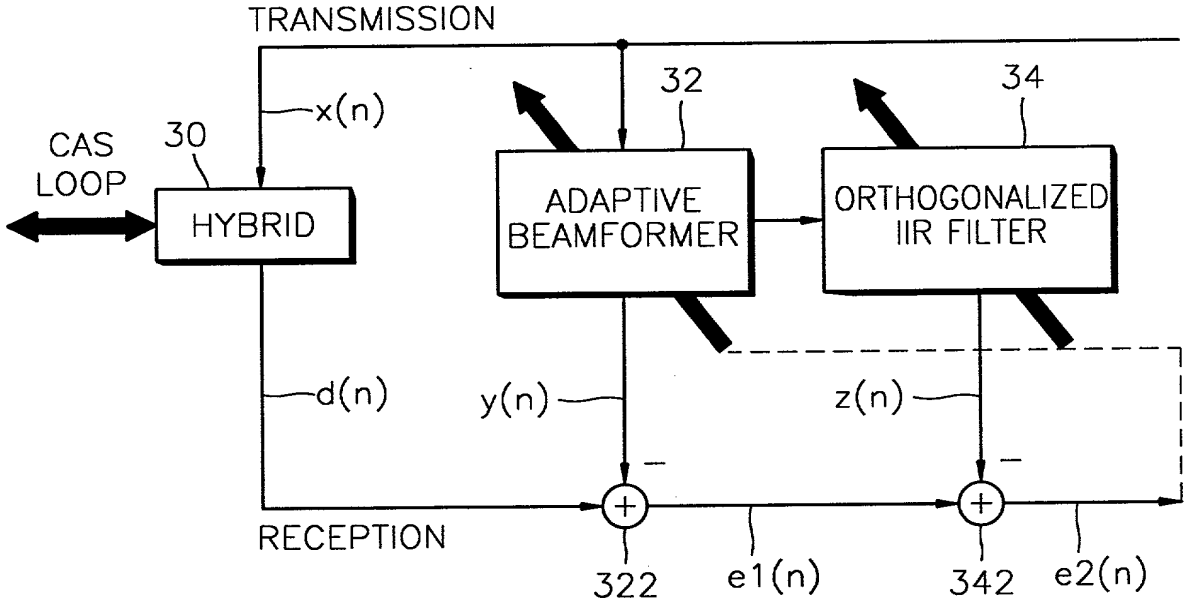
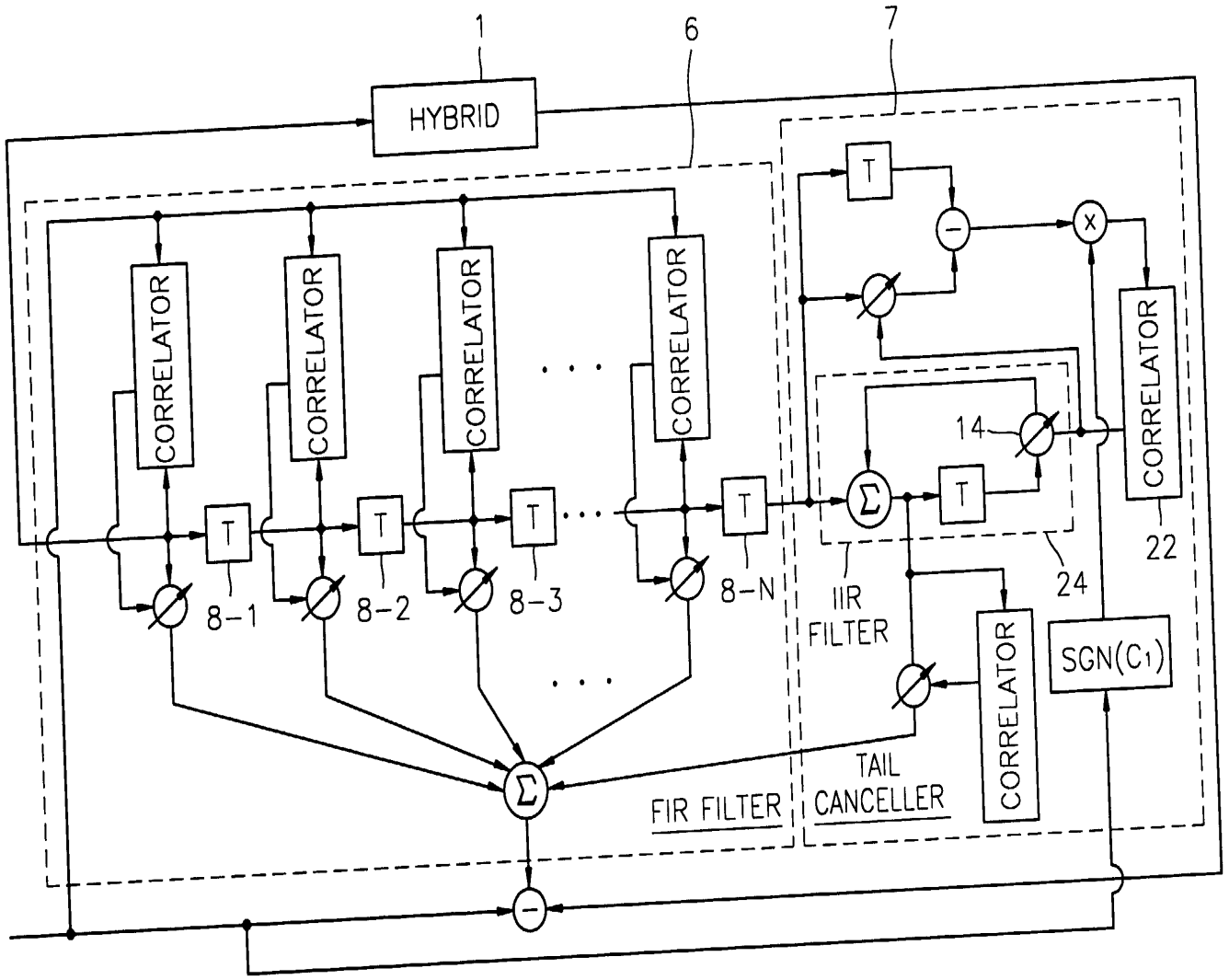
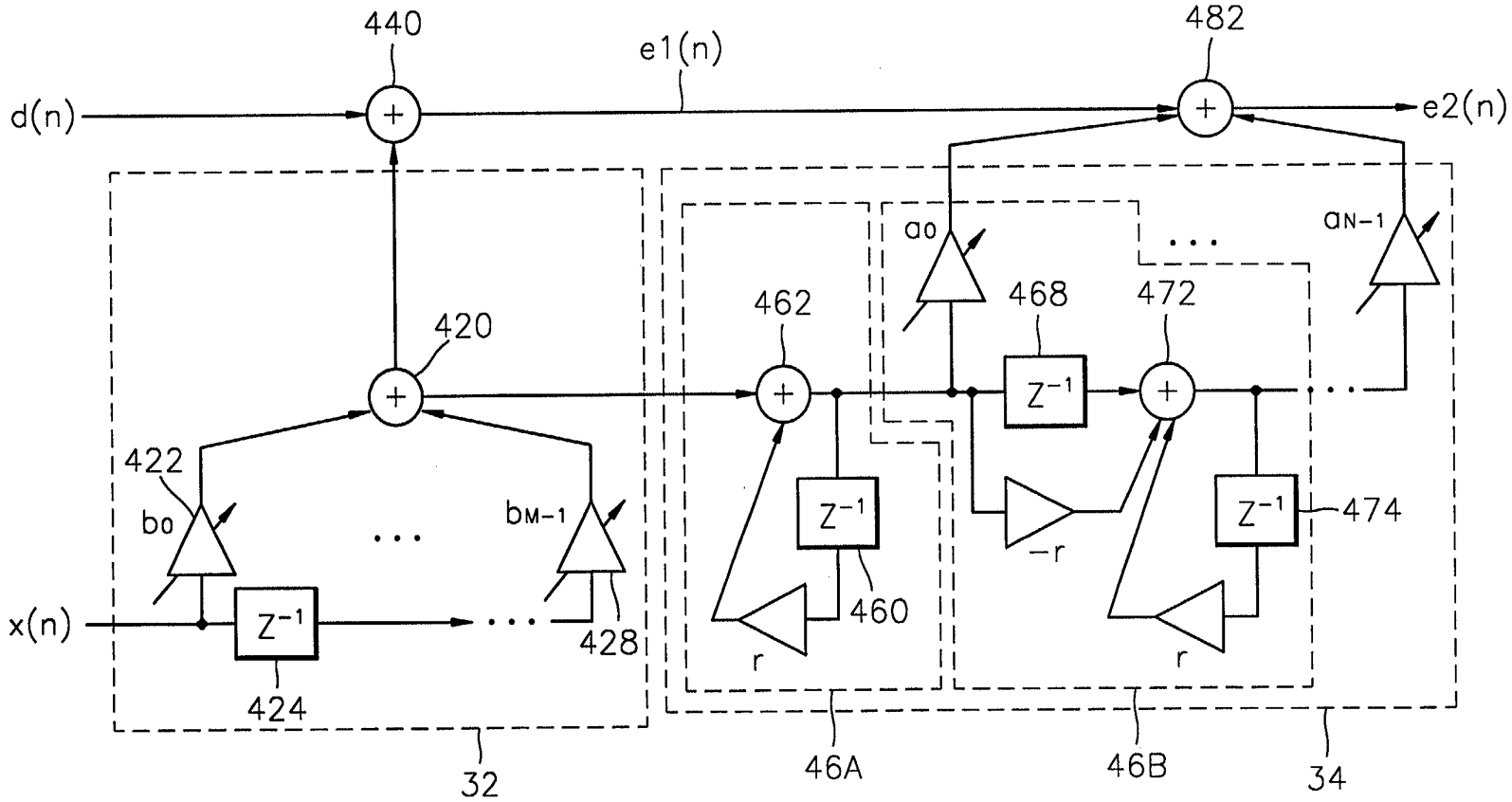


FIG. 2 (PRIOR ART)



SCAN

FIG. 4


440
e1(n)
482
d(n)
e2(n)
420
462
468
472
a0
aN-1
422
b0
bM-1
x(n)
Z-1
460
474
428
424
r
-r
32
46A
46B
34

Declaration and Power of Attorney For Patent Application
출원서원본상의 선서서와 위임장

Korean Language Declaration
한국어 선서서

하기한 발명자인 본인은 다음과 같이 선서합니다:

As a below named inventor, I hereby declare that:

본인의 주소, 우편주소 및 국적은 본인의 이름밑에 기재된 바와 같습니다.

My residence, post office address and citizenship are as stated next to my name.

본인은 아래에 기재된 발명에 대한 최초의 단독발명자 (단 한사람의 이름이 아래에 기재되었을 경우) 또는 공동발명자 (복수의 발명자가 아래에 기재되었을 경우) 라고 믿습니다.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

DIGITAL ECHO CANCELLATION DEVICE

아래 박스에 표시가 되어있지 않는 한 특허설명서는 여기에 첨부되어 있음:

the specification of which is attached hereto unless the following box is checked:

☐ __월 __일 미국출원번호 또는 PCT국제출원번호 _____로 출원되었으며 __월 __일 수정되었습니다. (만약 적용가능하면)

☐ was filed on _____ as United States Application Number or PCT International Application Number _____ and was amended on _____ (if Applicable).

본인은 상기 수정출원을 포함하여 특허설명서 내용을 검토하였으며 잘 파악하고 있음을 선서합니다.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

본인은 연방규정법전 37장 1.56편에 따라 특허자격에 있어 중요한 정보자료를 밝히는 것이 본인의 의무임을 인정합니다.

I acknowledge the duty to disclose information which is material to patentability as defined in the Title 37, Code of Federal Regulations, Section 1.56.

Korean Language Declaration
한국어 선서

본인은 미합중국법전 35장 119(a)-(d)편 또는 특허 또는 발명자 증서를 위한 그 어떤 외국출원의 365(b)편 또는 미국 이외에 최소한 한 국가를 지정하는 PCT국제출원의 365(a)편하의 외국우선권을 주장합니다. 아래 박스에 표시함으로서 기재하고 확인합니다.

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

이전의 외국 출원

(Number) (번호)	(Country) (국영)	(Day/Month/Year Filed) (출원년월일)	Priority Not Claimed 우선권 주장안함
99-35838	Rep. of Korea	27/August/1999	☐
			☐
			☐

본인은 미합중국법전 35장, 아래에 기재한 그 어떤 미국 가출원의 119(e)편하의 권한을 주장합니다.

I hereby claim the benefit under Title 35, United States Code, Section119(e) of any United States provisional application(s) listed below.

(Application No.) (출원번호)	(Filing Date) (출원일)	(Application No.) (출원번호)	(Filing Date) (출원일)

본인은 미합중국법전 35장, 그 어떤 미국출원의 120편 또는 미국을 지정하는 그 어떤 PCT국제출원의 365(c)편하의 권한을 주장합니다. 미합중국법전 35장 112편의 첫단락에 제시된 방법에 따라 이전의 미국 또는 PCT국제출원에 이제까지 기재된 본출원 내용은 밝혀지지 않았습니다. 본인은 연방규정법전 37장 1.56편에 따라 이전출원의 출원일과 국내 또는 PCT국제출원의 출원일사이에 유효된 특허자격에 있어 중요한 정보자료를 밝히는 것이 본인의 의무임을 인정합니다.

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112. I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.) (출원번호)	(Filing Date) (출원일)	(Status: Patented, Pending, Abandoned) (현황: 특허완료, 심사중, 포기됨)

본인이 아는 바에 의하면 여기에 작성된 모든 기재사항들과 정보자료로 제출한 모든 기재사항들은 진실된 것임을 선서하며, 그리고 이러한 진술이 고의적인 허위진술이거나 이와 비슷한 경우에는 미합중국법전 18장 1001편에 따라 벌금이나 징역형 또는 그 병과형으로 처벌되며, 허위진술은 본출원의 유효성이나 발급된 특허증을 위태롭게 할 수도 있다는 점을 선서합니다.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Korean Language Declaration
한국어 선서서

위임장: 본인은 본건출원과 관련된 모든 사무를 처리하기 위하여 대리인을 지명합니다. 상기 각자는 대리와 취소 및 업무제휴가 되어있는 대리인을 지명할 전권을 갖습니다. (성명 및 등록번호 기재)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

I hereby appoint John H. Mion, Reg. No. 18,879; Donald E. Zinn, Reg. No. 19,046; Thomas J. Macpeak, Reg. No. 19,292; Robert J. Seas, Jr., Reg. No. 21,092; Darryl Mexic, Reg. No. 23,063; Robert V. Sloan, Reg. No. 22,775; Peter D. Olexy, Reg. No. 24,513; J. Frank Osha, Reg. No. 24,625; Waddell A. Biggart, Reg. No 24,861; Robert G. McMorrow, Reg. No. 19,093; Louis Gubinsky, Reg. No. 24,835; Neil B. Siegel, Reg. No. 25,200; David J. Cushing, Reg. No. 28,703; John R. Inge, Reg. No. 26,916; Joseph J. Ruch, Jr., Reg. No. 26,577; Sheldon I. Landsman, Reg. No. 25,430; Richard C. Turner, Reg. No. 29,710; Howard L. Bernstein, Reg. No. 25,665; Alan J. Kasper, Reg. No. 25,426; Kenneth J. Burchfiel, Reg No. 31,333; Gordon Kit, Reg. No. 30,764; Susan J. Mack, Reg. No. 30, 951; Frank L. Bernstein, Reg, No. 31,484; Mark Boland, Reg No. 32,197; William H. Mandir, Reg. No. 32,156; Scott M. Daniels, Reg. No. 32,562; Brian W. Hannon, Reg. No. 32,778; Abraham J. Rosner, Reg. No. 33,276; Bruce E. Kramer, Reg. No. 33,725; Paul F. Neils, Reg. No. 33,102; and Brett S. Sylvester, Reg, No. 32,765, my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, and request that all correspondence about the application be addressed to SUGHRUE, MION, ZINN, MACPEAK & SEAS, PLLC. 2100 Pennsylvania Avenue, N.W., Washington, D.C. 20037-3202.

서신을 위한 주소:

Send Correspondence to:
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두째번 발명자의 서명 날짜	Second inventor's signature Date
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(세번째와 그외 합동발명자의 위와 비슷한 기재사항과 서명을 제공하십시요.)

(Supply similar information and signature for third and subsequent joint inventors.)